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<p>(57) Abstract</p> <p>A method and system for synchronizing multiple streams of isochronous and non-isochronous data (100) and navigating through the synchronized streams by reference to a common time base (210) and by means of a structured framework of conceptual events provides computer users with an effective means to interact with multimedia programs of speakers giving presentations (400). The multimedia programs consisting of synchronized video, audio, graphics, text, hypertext, and other data types can be stored on a server (130), and users can navigate and play them from a client CPU (110) over a non-isochronous network connection (150).</p>		

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**A METHOD AND SYSTEM FOR SYNCHRONIZING AND NAVIGATING
MULTIPLE STREAMS OF ISOCHRONOUS AND NON-ISOCHRONOUS
DATA**

5 BACKGROUND OF THE INVENTION

1. Field of the Invention

10 The present invention generally relates to the production and delivery of video recordings of speakers giving presentations, and, more particularly, to the production and delivery of digital multimedia programs of speakers giving presentations. These digital multimedia programs consist of multiple synchronized streams of isochronous and non-isochronous data, including video, audio, graphics, text, hypertext, and other data types.

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2. Description of the Prior Art

20 The recording of speakers giving presentations, at events such as professional conferences, business or government organizations' internal training seminars, or classes conducted by educational institutions, is a common practice. Such recordings provide access to the content of the presentation to individuals who were not able to attend the live event.

25 The most common form of such recordings is analog video taping. A video camera is used to record the event onto a video tape, which is subsequently duplicated to an analog medium suitable for distribution, most commonly a VHS

tape, which can be viewed using a commercially-available VCR and television set. Such video tapes generally contain a video recording of the speaker and a synchronized audio recording of the speaker's words. They may also contain a video recording of any visual aids which the speaker used, such as text or graphics projected in a manner visible to the audience. Such video tapes may also be edited prior to duplication to include a textual transcript of the audio component recording, typically presented on the bottom of the video display as subtitles. Such subtitles are of particular use to the hearing impaired, and if translated into other languages, are of particular use to viewers who prefer to read along in a language other than the language used by the speaker.

Certain characteristics of such analog recordings of speakers giving presentations are unattractive to producers and to viewers. Analog tape players offer limited navigation facilities, generally limited to fast forward and rewind capabilities. In addition, analog tapes have the capacity to store only a few hours of video and audio, resulting in the need to duplicate and distribute a large number of tapes, leading to the accumulation of a large number of such tapes by viewers.

Advancements in computer technology have allowed analog recordings of speakers giving presentations to be converted to digital format, stored on a digital storage medium, such as a CD-ROM, and presented using a computer CPU and display, rather than a VCR and a television set. Such digital recordings generally include both isochronous and non-isochronous data. Isochronous data is data that is time ordered and must be presented at a particular rate. The isochronous data contained in such a digital recording generally includes video and audio. Non-isochronous data may or may not be time ordered, and need not be presented at a particular rate. Non-isochronous data contained in such a digital recording may include graphics, text, and hypertext.

The use of computers to play digital video recordings of speakers giving presentations provides navigational capabilities not available with analog video tapes. Computer-based manipulation of the digital data offers random access to any point in the speech, and if there is a text transcript, allows the users to search
5 for words in the transcript to locate a particular segment of the speech.

Certain characteristics of state-of-the-art digital storage and presentation of recordings of speakers giving presentations are unattractive to producers and to viewers. There is no easy way to navigate directly to a particular section of a
10 presentation that discusses a topic of particular interest to the user. In addition, there is no easy way to associate a table of contents with a presentation, and navigate directly to section of the presentation associated with each entry in the table of contents. Finally, like analog tapes, CD-ROMs can store only a view
15 hours of digital video and audio, resulting in the need to duplicate and distribute a large number of CD-ROMs, leading to the accumulation of a large number of such CD-ROMs by viewers.

SUMMARY OF THE INVENTION

20 It is therefore an object of the present invention to provide a mechanism for synchronizing multiple streams of isochronous and non-isochronous digital data in a manner that supports navigating by means of a structured framework of conceptual events.

25 It is another object of the invention to provide a mechanism for navigating through any stream using the navigational approach most appropriate to the structure and content of that stream.

It is another object of the invention to automatically position each of the streams at the position corresponding to the selected position in the navigated stream, and simultaneously display some or all of the streams at that position.

- 5 It is another object of the invention to provide for the delivery of programs made up of multiple streams of synchronized isochronous and non-isochronous digital data across non-isochronous network connections.

- 10 In order to accomplish these and other objects of the invention, a method and system for manipulating multiple streams of isochronous and non-isochronous digital data is provided, including synchronizing multiple streams of isochronous and non-isochronous data by reference to a common time base, supporting navigation through each stream in the manner most appropriate to that stream, defining a framework of conceptual events and allowing a user to navigate through the streams using this structured framework, identifying the position in each stream
15 corresponding to the position selected in the navigated stream, and simultaneously displaying to the user some or all of the streams at the position corresponding to the position selected in the navigated stream. Further, a method and system of efficiently supporting sequential and random access into streams of isochronous and
20 non-isochronous data across non-isochronous networks is provided, including reading the isochronous and non-isochronous data from the storage medium into memory of the server CPU, transmitting the data from the memory of the server CPU to the memory of the client CPU, and caching the different types of data in the memory of the client CPU in a manner that ensures continuous display of the
25 isochronous data on the client CPU display device.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other objectives, aspects, and advantages of the present invention will be better understood from the following detailed description of
5 embodiments thereof with reference to the following drawings.

FIG. 1 is a schematic diagram of the organization of a data processing system incorporating an embodiment of the present invention.

10 FIGS. 2 and 3 are schematic diagrams of the organization of the data in an embodiment of the present invention.

FIG. 4 is a diagram showing how two different sets of "conceptual events" may be associated with the same presentation in an embodiment of the present
15 invention.

FIGS. 5, 6 and 9 are exemplary screens produced in accordance with an embodiment of the present invention.

20 FIGS. 7, 8, 10, and 11 are flow charts indicating the operation of an embodiment of the present invention.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

25 Referring now to the drawings, and more particularly to FIG. 1, there is shown, in schematic representation, a data processing system 100 incorporating the invention. Conventional elements of the system include a client central processing unit 110 which includes high-speed memory, a local storage device 112 such as a
30 hard disk or CD-ROM, input devices such as keyboard 114 and pointing device

116 such as a mouse, and a visual data presentation device 118, such as a computer display screen, capable of presenting visual data perceptible to the senses of a user, and an audio data presentation device 120, such as speakers or headphones, capable of presenting audio data to the senses of a user. Other conventional elements of the system include a server central processing unit 130 which includes high-speed memory, a local storage device 132 such as a hard disk or CD-ROM, input devices such as keyboard 134 and pointing device 136, and a visual data presentation device 138, and an audio data presentation device 140. The client CPU is connected to the server CPU by means of a network connection 150.

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The invention includes three basic aspects: (1) synchronizing multiple streams of isochronous and non-isochronous data, (2) navigating through the synchronized streams of data by means of a structured framework of conceptual events, or by means of the navigational method most appropriate to each stream, and (3) delivering the multiple synchronized streams of isochronous and non-isochronous data over a non-isochronous network connecting the client CPU and the server CPU.

15

An exemplary form of the organization of the data embodied in the invention is shown in FIG. 2 and FIG. 3. Beginning with FIG. 2, the video/audio stream 200 is of a type known in the art capable of being played on a standard computer equipped with the appropriate video and audio subsystems, such as shown in FIG. 1. An example of such a video/audio stream is Microsoft Corporation's AVI™ format, which stands for "audio/video interleaved." AVI™ and other such video/audio formats consist of a series of digital images, each referred to as a "frame" of the video, and a series of samples that make up the digital audio. The frames are spaced equally in time, so that displaying consecutive frames on a display device at a sufficiently high and constant rate produces the sensation of continuous motion to the human perceptual system. The rate of displaying frames typically must exceed ten to fifteen frames per second to achieve the effect of

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continuous motion. The audio samples are synchronized with the video frames, so that the associated audio can be played in synchronization with the displayed video images. Both the digital images and digital audio samples may be compressed to reduce the amount of data that must be stored or transmitted.

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A time base **210** associates a time code with each video frame. The time base is used to associate other data with each frame of video. The audio data, which for the purposes of this invention consists primarily of spoken words, is transcribed into a textual format, called the Transcript **220**. The transcript is
10 synchronized to the audio data stream by assigning a time code to each word, producing the Time-Coded Transcript **225**. The time codes (shown in angle-brackets) preceding each word in the Time-Coded Transcript correspond to the time at which the speaker begins pronouncing that word. For example, the time code **230** of 22.51 s is associated with the word **235** "the." The Time-Coded Transcript
15 may be created manually or by means of an automatic procedure. Manual time-coding requires a person to associate a time code with each word in the transcript. Automatic time coding, for example, uses a speech recognition system of a type well-known in the art to automatically assign a time code to each word as it is recognized and recorded. The current state of the art of speech recognition systems
20 renders automatic time coding of the transcript less economical than manual time coding.

Referring now to FIG. 3, the set **310** of Slides S1 **311**, S2 **312**, ... that the speaker used as part of the presentation may be stored in an electronic format of
25 any of the types well-known in the art. Each slide may consist of graphics, text, and other data that can be rendered on a computer display. A Slide Index **315** assigns a time code to each Slide. For example, Slide S1 **311** would have a time code **316** of 0 s, S2 **312** having a time code **317** of 20.40 s, and so on. The time code corresponds to the time during the presentation at which the speaker caused
30 the specified Slide to be presented. In one embodiment, all of the Slides are

contained in the same disk file, and the Slide Index contains pointers to the locations of each Slide in the disk file. Alternatively, each Slide may be stored in a separate disk file, and the Slide Index contains pointers to the files containing the Slides.

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An Outline **320** of the presentation is stored as a separate text data object. The Outline is a hierarchy of topics **321**, **322**, .. that describe the organization of the presentation, analogous to the manner in which a table of contents describes the organization of a book. The outline may consist of an arbitrary number of entries, and an arbitrary number of levels in the hierarchy. An Outline Index **325** assigns a time code to each entry in the Outline. The time code corresponds to the time during the presentation at which the speaker begins discussing the topic represented by the entry in the Outline. For example, topic **321**, "Introduction" has entry name "01" and time code **326** of 0 s, topic **322** "The First Manned Flight" has entry name "02" and time code **327** of 20.50 s, "The Wright Brothers" **323** has entry name "021" (and hence is a subtopic of topic **322**) with time code **328** of 120.05 s, and so on. The Outline and the Outline Index may be created by means of a manual or an automatic procedure. Manual creation is accomplished by a person viewing the presentation, authoring the Outline, and assigning a time code to each element in the outline. Automatic creation may be accomplished by automatically constructing the outline consisting of the titles of each of the Slides, and associating with each entry on the Outline the time code of the corresponding Slide. Note that manual and automatic creation may produce different Outlines.

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The set **330** of Hypertext Objects **331**, **332**, ... relating to the subject of the presentation may be stored in an electronic formats of various types well-known in the art. Each Hypertext Object may consist of graphics, text, and other data that can be rendered on a computer display, or pointers to other software applications, as spreadsheets, word processors, and electronic mail systems, as well as more

specialized applications such as proficiency testing applications or computer-based training applications.

5 A Hypertext Index table 335 is used to assign two time codes and a display location to each Hypertext Object. The first time code 336 corresponds to the earliest time during the presentation at which the Hypertext Object relates to the content of the presentation. The second time code 337 corresponds to the latest time during the presentation at which the Hypertext Object relates to the content of the presentation. The Object Name 338, as the name suggests, denotes the
10 Hypertext Object's name. The display location 339 denotes how the connection to the Hypertext Object, referred to as the Hypertext Link, is to be displayed on the computer screen. Hypertext Links may be displayed as highlighted words in the Transcript or the Slides, as buttons or menu items on the end-user interface, or in other visual presentation that may be selected by the user.

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It may be appreciated by one of ordinary skill in the art that other data types may be synchronized to the common time base in a manner similar to the approaches used to synchronize the video/audio stream with the Transcript, the Slides, and the Hypertext Objects. Examples of such other data types include
20 animations, series of computer screen images, and other specialty video streams.

An Outline represents an example of what is termed here a set of "conceptual events." A conceptual event is an association one makes with a segment of a data stream, having a beginning and end (though the beginning and
25 end may be the points), that represents something of interest. These data segments delineating a set of conceptual events may overlap each other, and furthermore, need not cover the entire data stream. An Outline represents a set of conceptual events that does cover the entire data stream and, if arranged hierarchically, such as with sections and subsections, has sections covering subsections. In the Outline
30 320 of FIG. 3, one has the sections 01:"Introduction" 321, 02:"The First Manned

Flight" 322 , and so on, covering the entire presentation. The subsections 021:"The Wright Brothers" 324, 022:"Failed Attempts" 324 and so on, represents another coverage of the same segment as 02:"The First Manned Flight" 322. In accordance with the principles of the present invention, multiple Outlines, created manually or automatically, may be associated with the same presentation, thereby allowing different users with different purposes in viewing the presentation to use the Outline most suitable for their purposes. These Outlines have been described from the perspective of having been created beforehand, but there is no reason, under the principles of the present invention, for this to be so. It should be readily understood by one of ordinary skill in the art that a similar approach would allow a user to create a set of "bookmarks" that denote particular segments, or user-chosen "conceptual events" within presentations. The bookmarks allow the user, for example, to return quickly to interesting parts of the presentation, or to pick up at the previous stopping point.

With reference to FIG. 4, the implementation of sets of conceptual events may be understood. There are time lines representing the various data streams, as for example, video 350, audio 352, slides 354 and transcript 356. There are two sets of conceptual events or data segments of these time lines shown, S_1 360, S_2 362, S_3 364, S_4 366, ... and S'_1 370, S'_2 372, S'_3 374, S'_4 376 , S'_5 378, ..., the first set indexed into the video 350 stream and second set indexed into the audio 352 stream. Thus, the first set S_1 360, S_2 362, S_3 364, etc., would respectively invoke time codes 380 and 381, 382 and 383, 384 and 385, etc., not only for the video 350 data stream, but for the audio 352 , slides 354 and transcript 356 streams. Similarly, the second set S'_1 370, S'_2 372, S'_3 384, etc., would invoke respectively time codes 390 (a point), 391 and 392, 393 and 394 (394 shown collinear with 384, whether by choice or accident), etc., respectively, not only on the audio 352 data stream, but on the video 350, slides 354 and transcript 356 streams. Consider the following example of a presentation of ice skating performed to music, with voice-over commentaries and slides showing the relative standings of the ice

skaters. A first Outline might list each skater and be broken down further into the individual moves of each skater's program. A second Outline might track the musical portion of the audio stream, following the music piece to piece, even movement to movement. Thus, one user might be interested in how a skater performed a particular move, while another user might wish to study how a particular passage of music inspired a skater to make a particular move. Note that there is no requirement that two sets of conceptual events track each other in any way, they represent two different ways of studying the same presentation. Furthermore, the examples showed sets of conceptual events indexed into isochronous data streams; it may be appreciated by someone of ordinary skill in the art that sets of conceptual events may be indexed into non-isochronous data streams as well. As was stated earlier, an Outline for a presentation may be indexed to the slide stream.

Referring now to the exemplary screen shown in FIG. 5, the exemplary screen 400 shows five windows 410, 420, 430, 440, 450 contained within the display. The Video Window 410 is used to display the video stream. The Slide Window 420 is used to display the slides used in the presentation. The Transcript Window 430 is used to display the transcribed audio of the speech. The Outline Window 440 is used to display the Outline of the presentation. The Control Panel 450 is used to control the display in each of the other four windows. The Transcript Window 430 includes a Transcript Slider Bar 432 that allows the user to scroll through the transcript, and Next 433 and Previous 434 Phrase Buttons that allow the user to step through the transcript a phrase at a time, where a phrase consists of a single line of the transcript. It also includes a Hypertext Link 436, as illustrated here in the form of the highlighted words, "Robert Jones", in the transcript. The Outline Window 440 includes an Outline Slider Bar 442 that allows the user to scroll through the outline, and Next 443 and Previous Entry buttons 444 that allow the user to jump directly to the next or previous topic. The Control Panel 450 includes a Video Slider Bar 452 used to select a position in the video

stream, and a Play Button 454 used to play the program. It also includes a Slider Bar 456 used to position the program at a Slide, and Previous 457 and Next 458 Slide Buttons used to display the next and previous Slides in the Slide Window 420. It also includes a Search Box 460 used to search for text strings (e.g., words) in the Transcript.

FIG. 5 shows the beginning of a presentation, corresponding to a time code of zero. The speaker's first slide is displayed in the Slide Window 410, the speaker's first words are displayed in the Transcript Window 430, and the beginning of the outline is displayed in the Outline Window 440. The user can press the play button 454 to begin playing the presentation, which will cause the video and audio data to begin streaming, the transcript and outline scroll in synchronization with the video and audio, and the slides to advance at the appropriate times.

Alternatively, the user can jump directly to a point of interest. FIG. 6 shows the result of the user selecting the second entry in the Outline from Outline Window 440', entitled "The First Manned Flight" (recall entry 322 of Outline 320 in FIG. 3). From the Outline Index 327 in FIG. 3, the system determines that the time code 327 of "The First Manned Flight" is 20.50 s. The system looks in the Slide Index 315 (also in FIG. 3) and determines that the second slide S2 begins at time code 317 of 20.40 s, and thus the second slide should be displayed in the Slide Window 420'. The system looks at the Time-Coded Transcript 215 (shown in FIG. 2), locates the word "the" 235 that begins on or immediately after time code of 20.50 s, and displays that word and the appropriate number of subsequent words to fill up the Transcript Window 430'. The effect of this operation is that the user is able to jump directly to a point in the presentation, and the system positions each of the synchronized data streams to that point, including the video in Video Window 410'. The user may then begin playing the presentation at this

point, or upon scanning the newly displayed slide and transcript jump directly to another point in the presentation.

Referring now to FIG. 7, the flowchart starting at 600 indicates the operation of an embodiment of the present invention. When the user slides the video slider bar 452 in FIG. 5, the Event Handler 601 in FIG. 7 receives a Move Video Slider Event 610. The Move Video Slider Event 610 causes the invention to calculate the video frame of the new position of the slider 452. The position of the video slider 452 is translated into the position in the video data stream in a proportional fashion. For example, if the new position of the video slider 452 is positioned half-way along its associated slider bar, and the video stream consist of 10,000 frames of video, then the 5,000th frame of video is displayed on the Video Window 420. The invention displays the new video frame 611, and computes the time code of the new video frame 612. Using this new time code, the system looks up the Slide associated with the displayed video frame, and displays 613 the new Slide in the Slide Window 410. Again using this new time code, the system looks up the Phrase associated with the displayed video frame, and displays the new Phrase 614 in the Transcript Window 430. Again using this new time code, the system looks up the Outline Entry associated with the displayed video frame, and displays the new Outline Entry 615 in the Outline Window 440. Finally, using this new time code, the system looks up the Hypertext Links associated with the displayed video frame, and displays them 616 in the appropriate place in the Transcript Window 430.

Referring back to FIG. 5, when the user moves the Slide Slider Bar 456 or presses the Previous 457 and Next 458 Slide Buttons, the Event Handler 601 in FIG. 7 receives a New Slide Event 620. The New Slide Event causes the system to display the selected new Slide 621 in the Slide Window 420, and to look up the time code of the new Slide in the Slide Index 622. Using the time code of the new Slide as the new time code, the system computes the video frame associated with

the new time code and displays the indicated video frame **623** in the Video Window. Again using the new time code, the system looks up the Phrase associated with the displayed Slide, and displays the new Phrase **624** in the Transcript Window **430**. Again using the new time code, the invention looks up the
5 Outline Entry associated with the displayed Slide, and displays the new Outline Entry **625** in the Outline Window **440**. Finally, using the new time code, the system looks up the Hypertext Links associated with the displayed Slide, and displays them **626** in the appropriate place in the Transcript Window **430**.

10 Referring again back to FIG. 5, when the user moves the Transcript Slider Bar **432** or presses the Next **433** or Previous **434** Phrase Buttons, the Event Handler **601** in FIG. 7 receives a New Phrase Event **630**. The New Phrase Event causes the system to display the selected new Phrase **631** in the Transcript Window **430**, and to look up the time code of the new Phrase in the Transcript Index **632**.
15 Using the time code of the new Phrase as the new time code, the invention computes the video frame associated with the new time code and displays the indicated video frame **633** in the Video Window **410**. Again using the new time code, the invention looks up the Slide associated with the displayed Phrase, and displays the new Slide **634** in the Slide Window. Again using the new time code,
20 the invention looks up the Outline Entry associated with the displayed Phrase, and displays the new Outline Entry **635** in the Outline Window **440**. Finally, using the new time code, the invention looks up the Hypertext Links associated with the displayed Phrase, and displays them **636** in the appropriate place in the Transcript Window **430**.
25

Referring yet again to FIG. 5, when the user types a search string into the Search Box **460** and initiates a search, the Event Handler **601** in FIG. 7 receives a Search Transcript Event **640**. The Search Transcript event causes the system to employ a string matching algorithm of a type well-known in the art to scan the
30 Transcript and locate the first occurrence of the search string **641**. The system uses

the Transcript Index to determine which Phrase contains the matched string in the Transcript 642. The system displays the selected new Phrase 631 in the Transcript Window, and looks up the time code of the new Phrase in the Transcript Index 632. Using the time code of the new Phrase as the new time code, the system
5 computes the video frame associated with the new time code and displays the indicated video frame 633 in the Video Window 410. Again using the new time code, the system looks up the Slide associated with the displayed Phrase, and displays the new Slide 634 in the Slide Window 420. Again using the new time code, the system looks up the Outline Entry associated with the displayed Phrase,
10 and displays the new Outline Entry 635 in the Outline Window 440. Finally, using the new time code, the system looks up the Hypertext Links associated with the displayed Phrase, and displays them 636 in the appropriate place.

Referring to FIG. 5, when the user moves the Outline Slider Bar 442 or
15 presses the Next 443 or Previous 444 Outline Entry Buttons, the Event Handler 601 in FIG. 7 receives a New Outline Entry Event 650. The New Outline Entry Event causes the system to display the selected new Outline Entry 651 in the Outline Window 440, and to look up the time code of the new Outline Entry in the Outline Index 652. Using the time code of the new Outline Entry as the new time code,
20 the system computes the video frame associated with the new time code and displays the indicated video frame 653 in the Video Window 410. Again using the new time code, the system looks up the Slide associated with the displayed Outline Entry, and displays the new Slide 654 in the Slide Window 420. Again using the new time code, the system looks up the Phrase associated with the displayed
25 Outline Entry, and displays the new Phrase 655 in the Transcript Window 430. Finally, using the new time code, the system looks up the Hypertext Links associated with the displayed Outline Entry, and displays them 656 in the appropriate place in the Transcript Window 430.

Referring again to FIG. 5, when the user selects a Hypertext Link 436, the Event Handler 601 in FIG. 7 receives a Display Hypertext Object 660. The system displays the data object pointed to by the selected Hypertext Link 661.

5 Whenever the system is in a stationary state, that is, when no video/audio stream is being played, the system maintains a record of the current time code. The data displayed in FIGS. 4 and 5 always correspond to the current time code. When the user presses the Play Button 454, the Event Handler 601 in FIG. 5 receives a Play Program Event 670. The system begin playing the video and audio
10 streams, starting at the current time code. Referring now to FIG. 8, as each new video frame is displayed 700, the system uses the time code of the displayed video frame to check the Transcript Index, the Slide Index, the Outline Index, and Hypertext Index and determine if the data displayed in the Slide Window 420, Transcript Window 430, or Outline Window 440 must be updated, or if new
15 Hypertext Links must be displayed in the Transcript Window 430. If the time code of the new video frame corresponds to the time code of the next Phrase 710, the system displays the next Phrase 711 in the Transcript Window 430. If the time code of the new video frame corresponds to the time code of the next Slide 720, the system displays the next Slide 721 in the Slide Window 420. If the time code
20 of the new video frame corresponds to the time code of the next Outline Entry 730, the system displays the next Outline Entry 731 in the Outline Window 440. Finally, if the time code of the new video frame corresponds to the time codes of a different set of Hypertext Links than are currently displayed 740, the system displays the new set of Hypertext Links 741 at the appropriate places on the
25 display in the Transcript Window 430.

It may be appreciated by one of ordinary skill in the art that the textual transcript may be translated into other languages. Multiple transcripts, corresponding to multiple languages, may be synchronized to the same time base,
30 corresponding to a single video/audio stream. Users may choose which transcript

language to view, and may switch among different transcripts in different languages during the operation of the invention.

Furthermore, multiple synchronized streams of each data type may be incorporated into a single multimedia program. Multiple video/audio streams, each corresponding to different video resolution, audio sampling rate, or data compression technology, may be included in a single program. Multiple sets of slides, hypertext links, and other streams of isochronous data types may also be included in a single program. One or more of each data type may be displayed on the computer screen, and users may switch among the different streams of data available in the program.

The present invention is compatible with operating with a collection of many presentations, and to assist users in locating the particular portion of the particular presentation that most interests them. The presentations are stored in a data base of a type well-known in the art, which may range from a simple non-relational data base that stores data in disk files to a complex relational or object-oriented data base that stores data in a specialized format. Referring to the exemplary screen 800 depicted in FIG. 9, users can issue structured queries or full text queries to identify programs they wish to view. The user types in a query in the query type-in box 810. The titles of the programs that match the query are displayed in the results box 820. Structured queries are queries that allow the user to select programs on the basis of structured information associated with each program, such as title, author, or date. Using any of the structured query engines well-known in the art, the user can specify a particular title, author, range of dates, or other structured query, and select only those programs which have associated structured information that matches the query. Full-text queries are queries that allow the user to select programs on the basis of text associated with each program, such as the abstract, transcript, slides, or ancillary materials connected via hypertext. Using any of the full-text search engines known in the art, the user can

specify a particular combination of words and phrases, and select only those programs which have associated text that matches the full-text query. Users can also select which of the associated text elements to search. For example, the user can specify to search only the transcript, only the slides, or a combination of both.

5 When the text associated with a program matches the user's query, the user can jump directly to the matched text, and display all of the other synchronized multimedia data types at that point in the program.

Full-text queries can be manually constructed by the users, or they can be automatically constructed by the invention. Such automatically-constructed queries are referred to as "agents." FIG. 10 presents a flow chart of the agent mechanism starting at 900. When the user displays a program 910, the system constructs a summary of the program 920. The summary of the program may be constructed in multiple alternative ways. Each program may have associated with it a list of

15 keywords that describe the major subjects discussed in the program. In this case, constructing the summary simply involves accessing this predefined list of keywords. Alternatively, any text summarization engine well-known in the art may be run across the text associated with program, including the abstract, the transcript, and the slides, to generate a list of keywords that describe the major

20 subjects discussed in the program. This summary is added to the user's profile 930. The user's profile is a list of keywords that collectively describe the programs that the user has viewed in the past. Each time the user views a new program, the keywords that describe that program are added to the user's profile. In this manner, the agent "learns" which subjects are most interesting to the user, and

25 continues to learn about the user's changing interests as the user uses the system. The agent mechanism also incorporates the concept of memory. Each keyword that is added to the user's profile is labeled with the date at which its associated program was viewed. Whenever the agent mechanism is initiated, the difference between the current date and the date label on each keyword is used to assess the

30 relative importance of that keyword. Keywords that entered the profile more

recently are treated as more important than keywords that entered the profile in the distant past. On specified events, such as the user logging into the system, the agents mechanism is initiated 901. The system creates a query from the current user's profile 940. The list of keywords in the profile are reorganized into the query syntax required by the full-text search engine. The ages of the keywords are converted into the relative importance measure required by the full-text search engine. The query is run against all of the programs on the server 950, and the resulting list of programs are presented to the user 960. This list of programs constitutes the programs which the system has determined may be of interest to the user, based on the user's past viewing behavior.

In addition, users can create their own agents by manually constructing a query that describe their ongoing interest. Each time the agents' mechanism is initiated, the user's manually-constructed agents are executed along with the system's automatically-constructed agent, and the selected programs are presented to the user.

The user can create "virtual conferences" that consist of user-defined aggregations of programs. To create a virtual conference, a user composes and executes a query that selects a set of programs that share a common attribute, such as author, or discuss a common subject. This thematic aggregation of programs can be named, saved, and distributed to other users interested in the same theme.

The user can construct "synthetic programs" by sequencing together segments of programs from multiple different programs. To create a synthetic program, the user composes and executes a query, specifying that the invention should select only those portions of the programs that match the query. The user can then view the concatenated portions of multiple programs in a continuous manner. The synthetic program can be named, saved, and distributed to other users interesting in the synthetic program content.

Referring now to FIG. 11, which will be used to describe the operation of an embodiment of the present invention across a non-isochronous network connection. This embodiment incorporates a cooperative processing data distribution and caching model that enables the isochronous data streams to play
5 continuously immediately following a navigational event, such as moving to the next slide or searching to a particular word in the transcript.

After the process starts 1000, when the user first selects a program to play 1001, the system downloads the selected portions of the non-isochronous data from
10 the server to the client. The downloaded non-isochronous data includes the Slide Index, the Slides, the Transcript Index, the Transcript, and the Hypertext Index. The downloaded non-isochronous data is stored in a disk cache 1010 on the client. The purpose of pre-downloading this non-isochronous data is to avoid having to
15 transmit it over the network connection simultaneously with the transmission of the isochronous data, thereby interrupting the transmission of the isochronous data. The Hypertext Objects are not pre-downloaded to the client; rather, the system is designed to pause the transmission of the isochronous data to accommodate the downloading of any Hypertext Objects. At the end of playing a program, the client
20 disk cache is emptied in preparation for use with another program.

In addition to downloading portions of the non-isochronous data, the system downloads a segment of the isochronous data from the server to a memory cache on the client. The downloaded isochronous data includes the initial segment of the video data and the corresponding initial segment of the audio data. The amount of
25 isochronous data downloaded typically ranges from 5 to 60 seconds, but may be more or less. The downloaded isochronous data is stored in a memory cache 1020 on the client.

When the user presses the Play Button, the Event Handler 1030 receives a
30 Play Program Event 1040. The system begins the continuous delivery of the

isochronous data to the display devices 1041. Based on the time code of the currently displayed video frame, it also displays the associated non-isochronous data 1042, including the Transcript, the Slides, and the Hypertext Links. As the system streams the isochronous data to the display devices, it depletes the memory cache. When the amount of isochronous data in the memory cache falls below a specified threshold, the system causes the client CPU to send a request to the server CPU for the next contiguous segment of isochronous data 1043. This threshold typically works out to be on the order of 5-10 seconds, with a worst-case scenario of 60 seconds. It should be appreciated by one of ordinary skill in art that factors such as network capacity and usage should affect the choice of threshold. Upon receiving this data, the client CPU repopulates the isochronous data memory cache. If, as anticipated, the client CPU experiences a delay in receiving the requested data, caused by the non-isochronous network connection, the client CPU continues to deliver isochronous data remaining in its memory cache in a continuous stream to the display device, until that cache is exhausted.

The method for repopulating the client's memory cache is a critical element in supporting efficient random access into isochronous data streams over a non-isochronous network. The method for downloading the isochronous data from the server to the memory cache on the client is designed to balance two competing requirements. The first requirement is for continuous, uninterrupted delivery of the isochronous data to the video display device and speakers attached to the client CPU. The network connection between the client and server is typically non-isochronous, and may introduce significant delays in the transmission of data from the client to the server. In practice, if the memory cache on the client becomes empty, requiring client to send a request across the network to the server for additional isochronous data, the amount of time needed to send and receive the request will cause the interruption of play of the isochronous data. The requirement for continuous delivery thus encourages the caching of as much data as possible on the client. The second requirement is to minimize the amount of data

that is transmitted across the network. In practice, multiple users share a fixed amount of network bandwidth, and transmitting video and audio data across a network consumes a substantial portion of this limited resource. It is anticipated that a common user behavior will be to use the random access navigation capabilities to reposition the program. But the act of repositioning the program invalidates all or part of the data stored in the memory cache in the client. The larger the amount of data that is stored in the memory cache on the client, the more data is wasted upon repositioning the program, and thus the more network bandwidth was wasted in sending this unused data from the server to the client. Thus the requirement for minimizing the amount of data transmitted across the network encourages the caching of as little data as possible on the client.

The present invention balances the need for continuous delivery of isochronous data to the display devices with the need to avoid wasting network bandwidth by implementing a novel cooperative processing data distribution and caching model. The memory cache on the client is designed specifically for compressed isochronous data, and more specifically for compressed digital video data. The caching strategy differs markedly from traditional caching strategies. Traditional caching strategies measure the number of bytes of data in the cache, and repopulate the cache when the number of bytes falls below a specified threshold. By contrast, one embodiment of the present invention measures the number of *seconds* of isochronous data in the memory cache, and repopulates the cache when the number of seconds falls below a specified threshold. Due to the inherent inhomogeneities in video compression, a fixed number of seconds of compressed video data does not correspond to a fixed number of bytes of data. For video data streams that compress into a smaller than average number of bytes per second, the cooperative distribution and caching model reduces the amount of data sent across the network compared to a traditional caching scheme. For video data streams that compress into a larger than average number of bytes per second, the cooperative distribution and caching model guarantees a certain number of seconds

of video data cached on the server, reducing the likelihood of interrupted play of the video data stream compared to a traditional caching scheme.

5 In addition to designing the memory cache to contain a range of a number of seconds of isochronous data, the memory cache employs a policy of *unbalanced look ahead and look behind*. *Look ahead* refers to caching the isochronous data corresponding to "N" seconds into the future. This isochronous data will be delivered to the display device under the normal operation of playing the program. *Look behind* refers to caching the isochronous data corresponding to "M" seconds
10 into the past. This isochronous data will be delivered to the display device under the frequent operation of replaying the previously played few seconds of the program. *Unbalanced* refers to the policy of caching a different amount (that is, a different number of seconds) of look ahead and look behind data. Generally, more look ahead data is cached than look behind data, typically in the approximate ratio
15 of 7:1. It can be appreciated by one of ordinary skill in the art that different caching policies can be employed in anticipation of different common user behaviors. For example, the use of a circular data structure, a structure well-known in the art, may effect this operation.

20 During program play 1040, the server sends data to the client at the nominal rate of one second of isochronous data each second. The server adapts to the characteristics of the network, bursting data if the network supports a high burst rate, or steadily transmitting data if the network does not support a high burst rate. The client monitors its memory cache, and sends requests to the server to speed up
25 or slow down. The client also sends requests to the server to stop, restart at a new place in the program, or start playing a different program.

The system administrator can specify how much network bandwidth is available to the system, for each individual program, and collectively across all
30 programs. The system automatically tunes its memory caching scheme to reflect

these limits. If the transmitted data would exceed the specified limits, the system automatically drops video frames as necessary.

When the user performs a navigational activity, such as moving to the next
5 slide or searching to a particular word in the transcript, the Event Handler 1030
receives a Navigational Event 1050. The system computes the time base value of
the new position 1051. It then downloads a new segment of the isochronous data
from the server to the memory cache on the client 1052. The downloaded
isochronous data includes a segment of the video data and a corresponding segment
10 of the audio data. The system then displays the video frame corresponding to the
current time base value, and the non-isochronous data corresponding to the
displayed video frame 1053.

When the user selects a hypertext link, the Event Handler 1030 receives a
15 Display Hypertext Object Event 1060. The system pauses the play of the program
1061. The client CPU requests that the server CPU send the Hypertext Object
across the network connection 1062, and upon receiving the Hypertext Object,
causes it to be displayed 1063.

20 Referring back to FIG. 1, the server 130 records the actions of each user,
including not only which programs each user viewed, but also which portions of
the programs each user viewed. This record can be used for usage analysis, billing,
or report generation. The user can ask the server 130 for a usage summary, which
contains an historical record of that particular user's usage. A manager or system
25 administrator can ask the server 130 for a summary across some or all users,
thereby developing an understanding of the patterns of usage. One might use any
of the data mining tools as is known in the art for assisting in this purpose.

The usage record may serve as a guide to restructure old programs or to
30 structure new ones, having learned what works from a presentation perspective and

what does not, for example. The usage record furthermore enables the system to notify users of changing data. The list of users who have viewed a program can be determined from the usage records. If a program is updated, the system reviews the usage record to determine which users have viewed the program, and notifies
5 them that the program that they previously viewed has changed.

While the present invention has been described in terms of a few embodiments, the disclosure of the particular embodiment disclosed herein is for the purposes of teaching the present invention and should not be construed to limit
10 the scope of the present invention which is solely defined by the scope and spirit of the appended claims.

Having thus described our invention, what we claim as new and desire to secure by Letters Patent is as follows:

1 1. A method of manipulating a plurality of streams of isochronous and non-
2 isochronous digital data comprising the steps of:
3 synchronizing the plurality of streams of isochronous and non-isochronous
4 data by reference to a common time base;
5 navigating to a position in any one of the plurality of streams using at least
6 one of a sequential and a random access approach available for and adapted to the
7 structure and contents of that stream,
8 identifying positions for each of the plurality of streams corresponding to
9 the position in the navigated stream; and
10 simultaneously displaying at least some of the plurality of streams at the
11 positions corresponding to the position in the navigated stream.

1 2. The method of claim 1, further comprising the step of delivering the
2 plurality of streams of synchronized isochronous and non-isochronous data from a
3 server to a client over a non-isochronous network.

1 3. The method of claim 1, further comprising the step of caching isochronous
2 data on the client, and modulating the delivery of the isochronous data over the
3 network in a manner that maintains a predetermined range of time's worth of data
4 cached on the client.

1 4. The method of claim 1, further comprising the step of translating the
2 transcript stream into one or more foreign languages, and including a plurality of
3 such transcripts, each synchronized to a common time base and each independently
4 navigable.

1 5. A system for interacting with a computerized presentation comprising:

2 a plurality of isochronous and non-isochronous data streams, wherein each
3 of the plurality of streams are synchronized together by reference to a common
4 time base;

5 for each of the plurality of data streams, means for at least one of sequential
6 and random access navigation of such data stream, and means for display of such
7 data stream; and

8 identification means, coupled to each of the navigation means, wherein,
9 given a position in one of the plurality of data streams as pointed to by its
10 associated navigation means, the identification means provides, via the common
11 time base, the corresponding positions in the other of the plurality of data streams.

1 6. The system of claim 5 further comprising:

2 a server for storing the plurality of isochronous and non-isochronous data
3 streams;

4 a client for containing the display and the access navigation means of such
5 data streams; and

6 a non-isochronous network for delivery of such data streams from the server
7 to the client device;

8 the client further including a data cache and a modulation means both
9 coupled to the network, wherein one or more of the data streams delivered by the
10 network are stored in the data cache, and further wherein the modulation means
11 maintains a predetermined range of time's worth of data within the data cache.

1 7. The system of claim 5, wherein one of more of the digital data streams
2 corresponds to a speaker giving an informational or educational presentation.

1 8. The system of claim 5, wherein at least one of the isochronous data streams
2 includes digital video.

1 9. The system of claim 5, wherein at least one of the isochronous data streams
2 includes digital audio.

1 10. The system of claim 5, wherein at least one of the non-isochronous data
2 streams includes slides.

1 11. The system of claim 5, wherein at least one of the non-isochronous data
2 streams includes hypertext links to related data objects.

1 12. The system of claim 5, wherein at least one of the non-isochronous data
2 streams includes an outline of the presentation.

1 13. The system of claim 5, wherein at least one of the non-isochronous data
2 streams includes a transcript of spoken words in the presentation.

1 14. The system of claim 13, wherein the random access navigation means
2 corresponding to the transcript further includes a full-text search engine.

1 15. The system of claim 14, further comprising:
2 a plurality of computerized presentations which may be selected by a user,
3 at least some of the presentations including one or more keywords associated
4 therewith; and
5 a profiling means which maintains a user profile on each user, the user
6 profile including an aggregation of at least some of the keywords of the
7 presentations selected by the user.

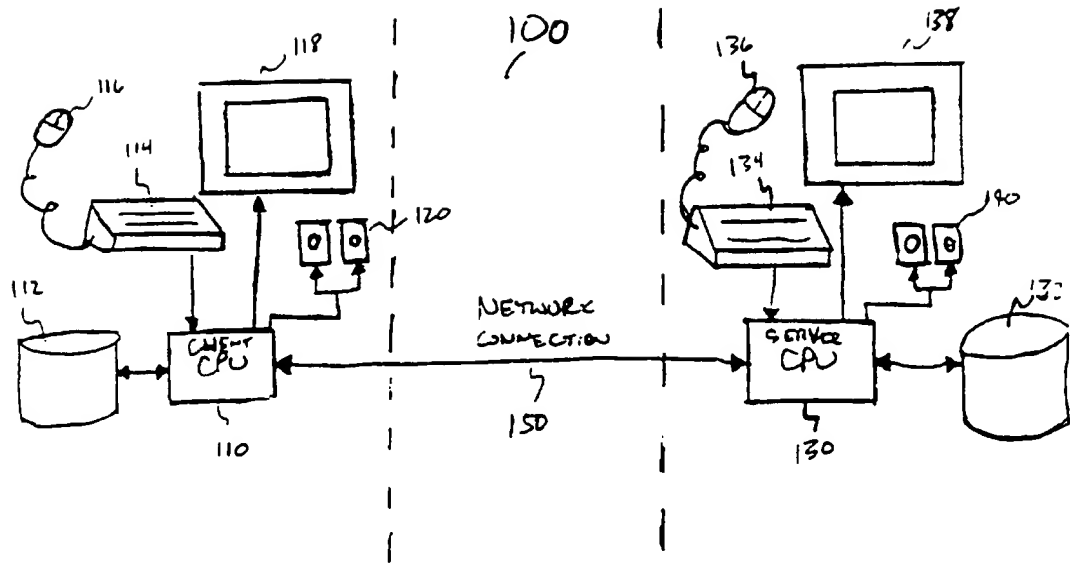
1 16. A system for interacting with a computerized presentation comprising:
2 a plurality of isochronous and non-isochronous data streams;
3 two or more sets of conceptual events, each set indexed into one of the
4 plurality of data streams;

5 for each of the plurality of data streams, means for navigation and display
6 of such data stream, and for those data streams having a set of conceptual events,
7 the means for navigation including a means for selection of a conceptual event;
8 an identification means, coupled to each navigation and each display means,
9 wherein, given a selected conceptual event, provides the positions in each of the
10 plurality of data streams corresponding to the event.

1 17. The system of claim 16 wherein a first set of conceptual events is indexed
2 into an isochronous data stream and a second set of conceptual events is indexed
3 into a non-isochronous data stream.

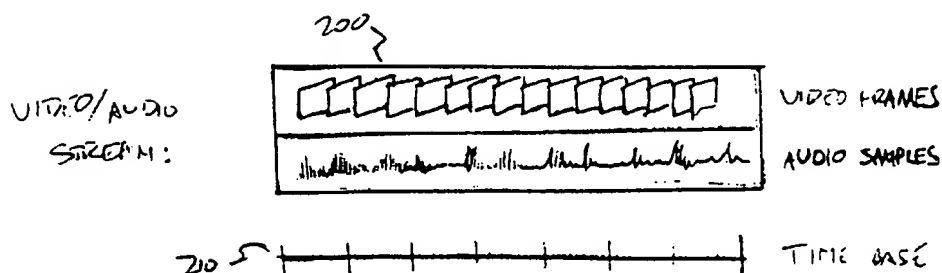
1 18. The system of claim 16 further comprising a bookmarking means for ad hoc
2 creation of conceptual events.

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FIG. 1

2/11

FIG. 2



TRANSCRIPT:

220

Hello, I'm Robert Jones, and I'm going to tell you about the history of manned flight. This talk will take about 20 minutes. The first manned flight was the culmination of centuries of research and development.

215

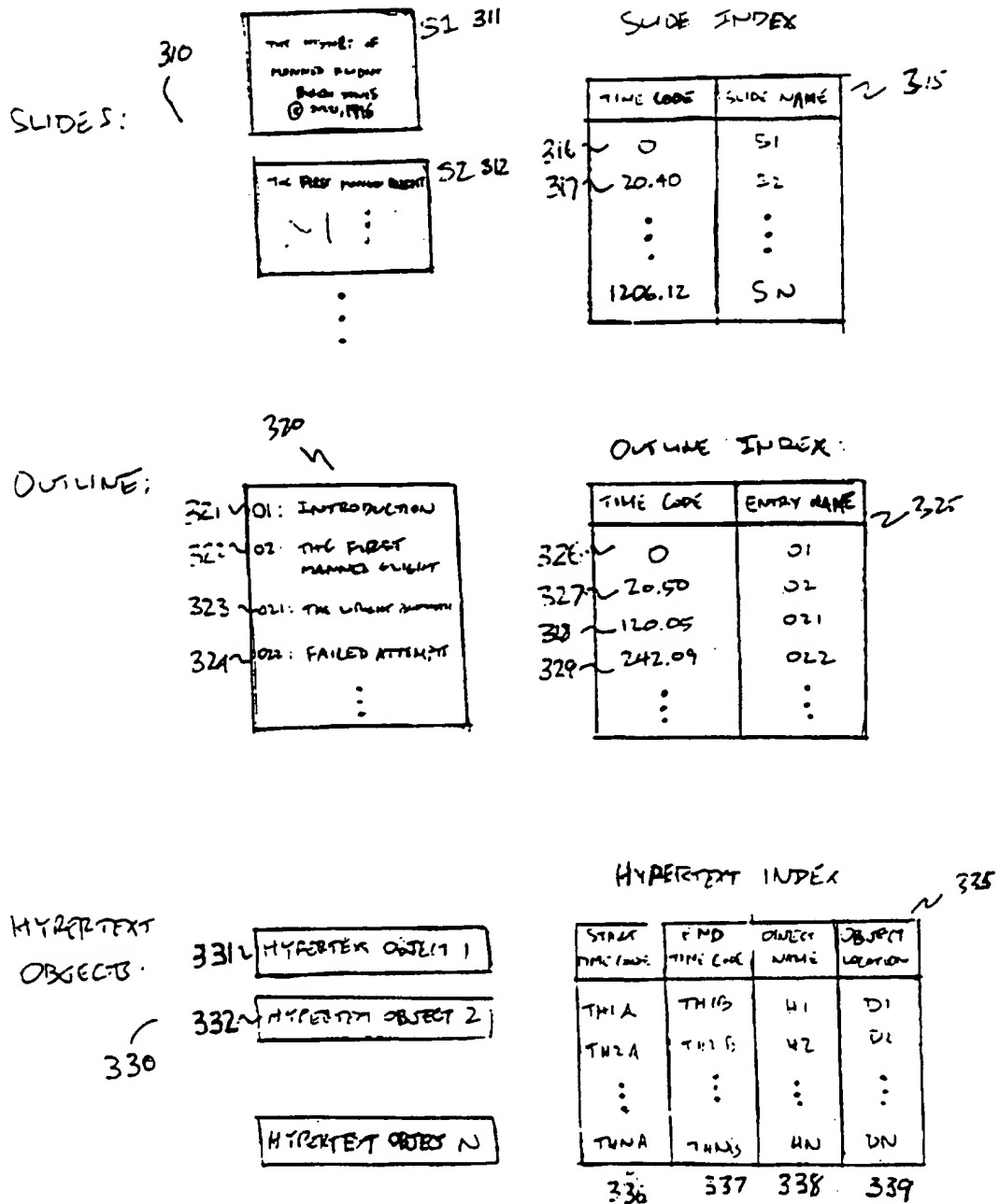
TIME-CODED
TRANSCRIPT:

220 235

<0> Hello <0.7> I'm <0.41> Robert Jones <0.7> I'm going to tell you about the history of manned flight. This talk will take about 20 minutes. The first manned flight was the culmination of centuries of research and development.

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FIG. 3



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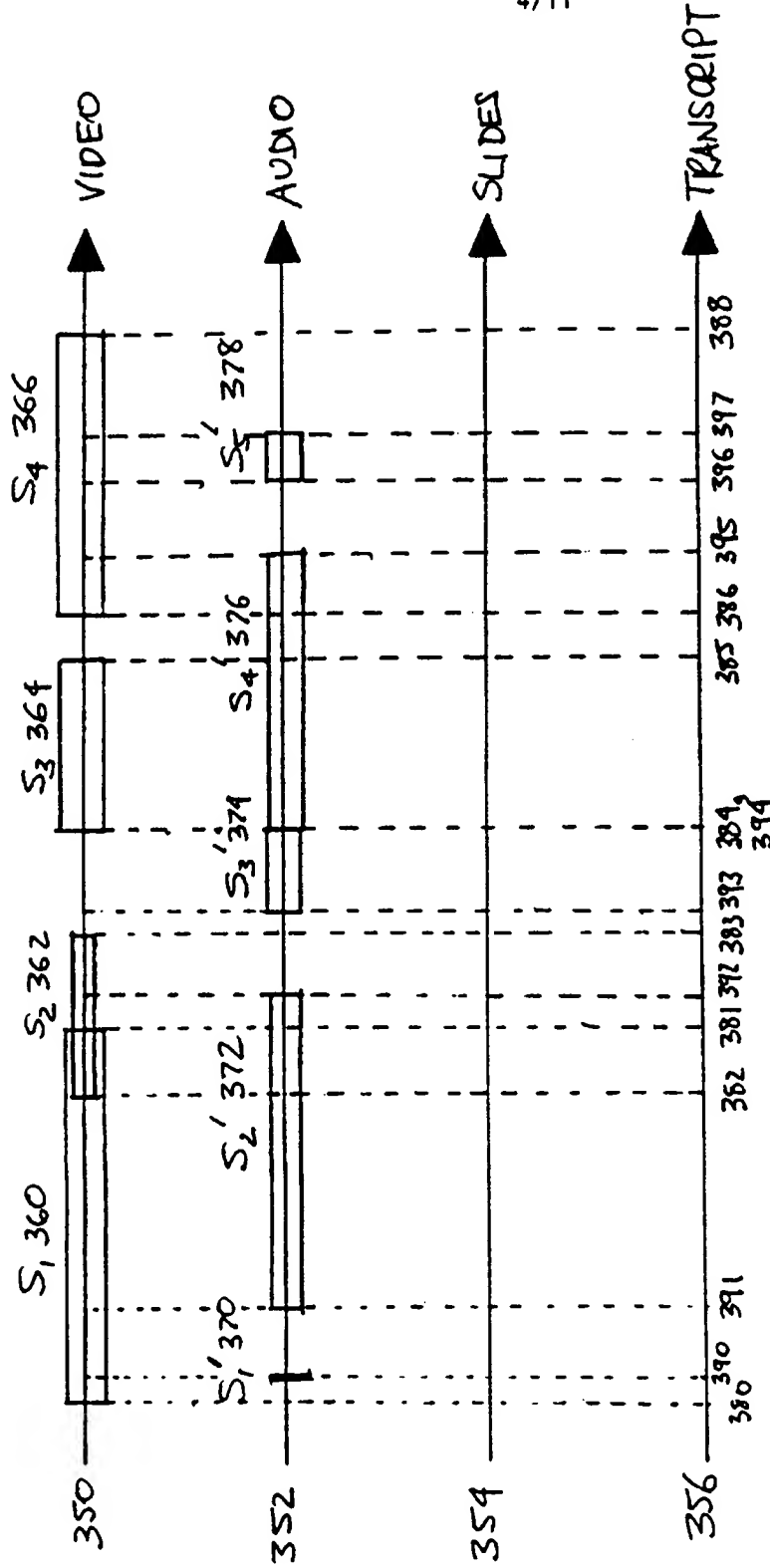
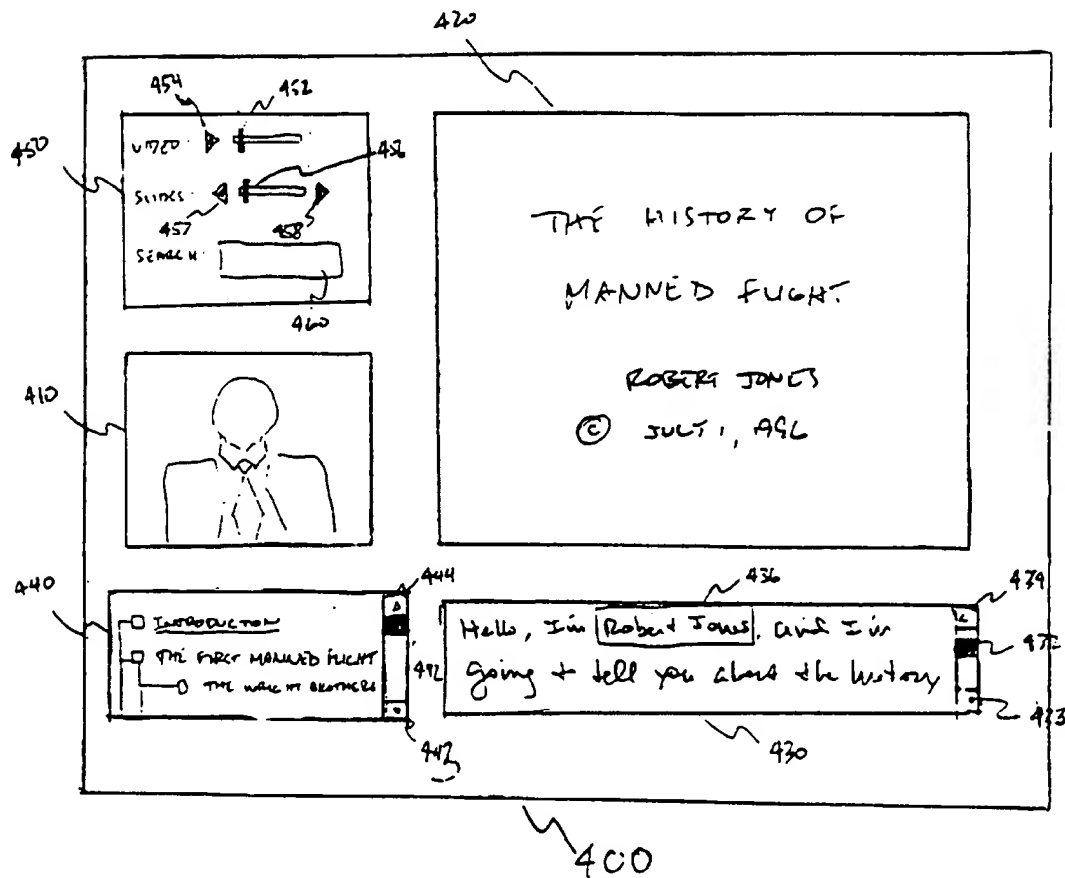


FIG. 4

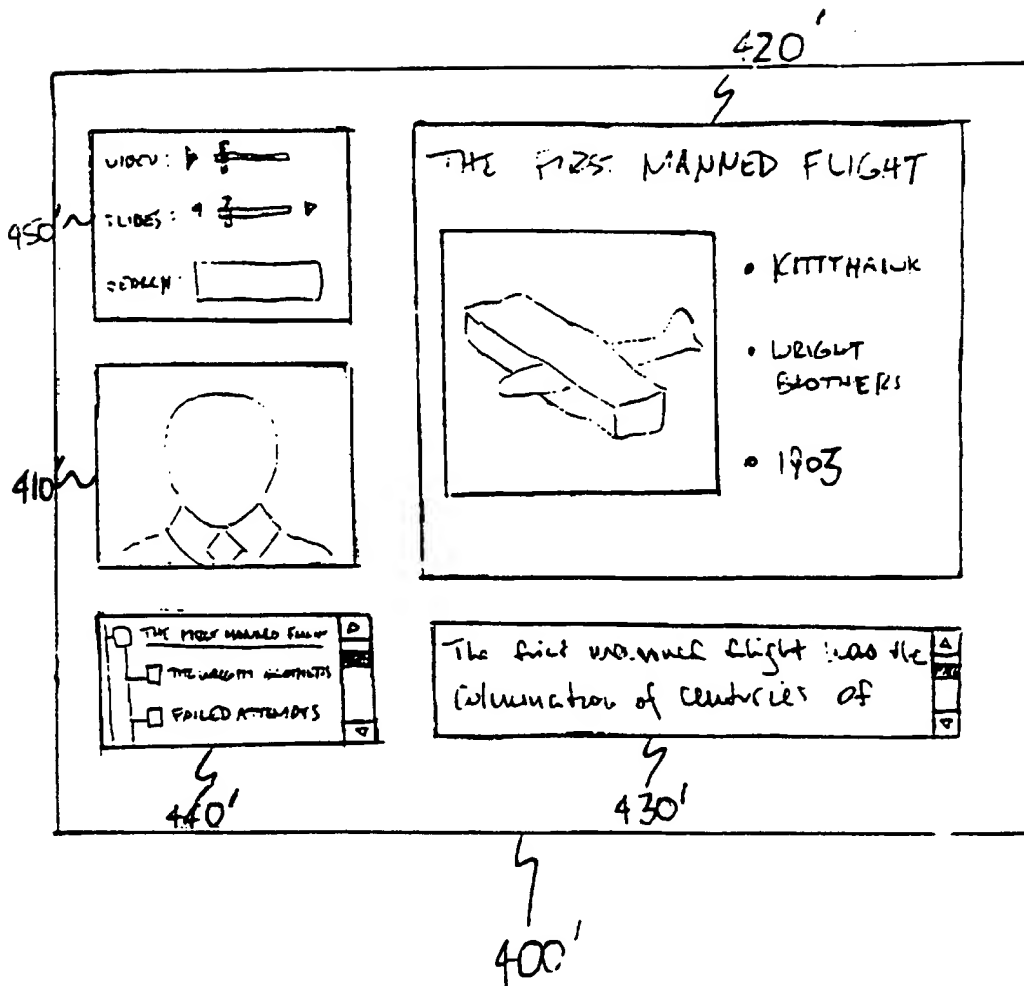
5/11

FIG. 5



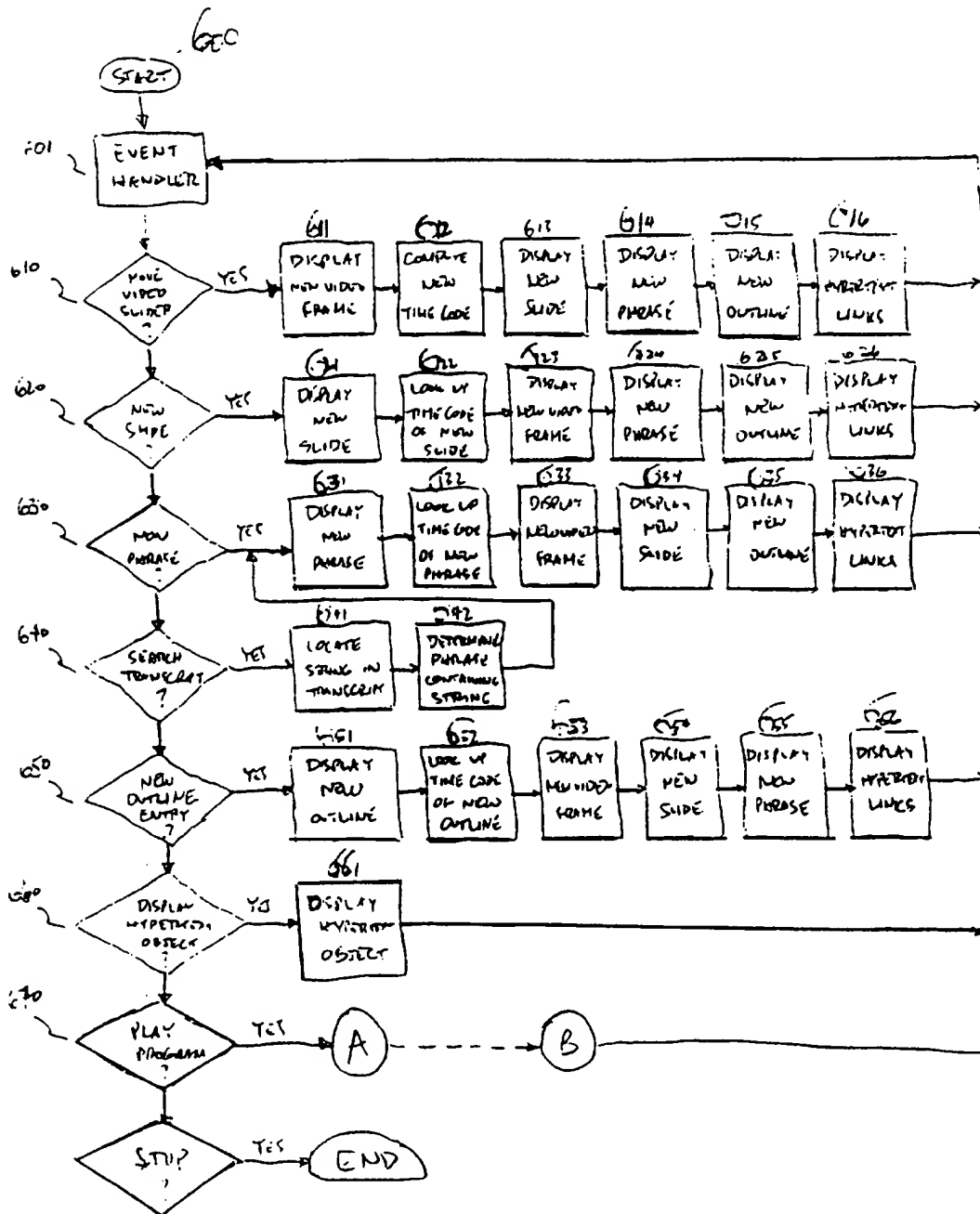
6/11

FIG. 6



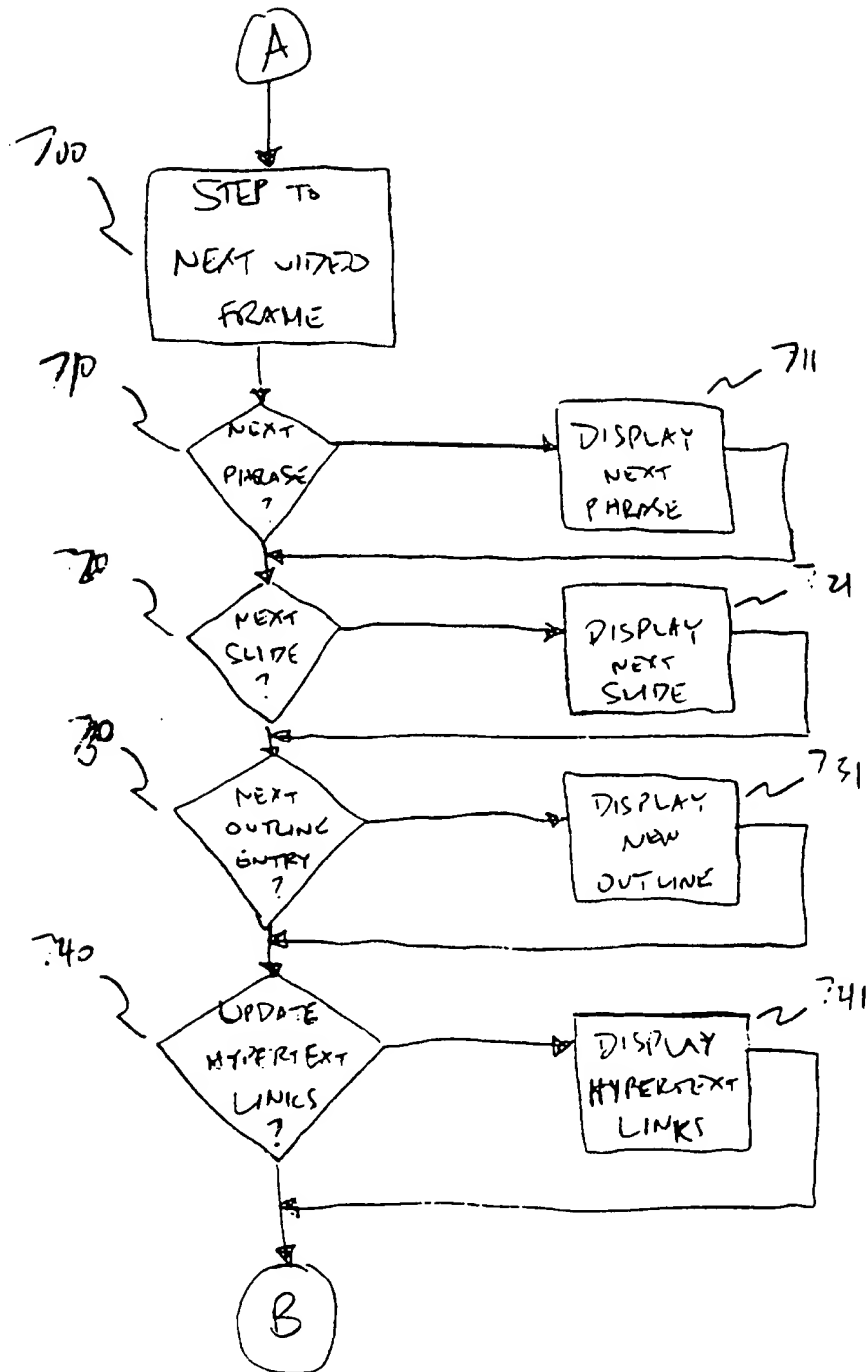
7/11

FIG 7.



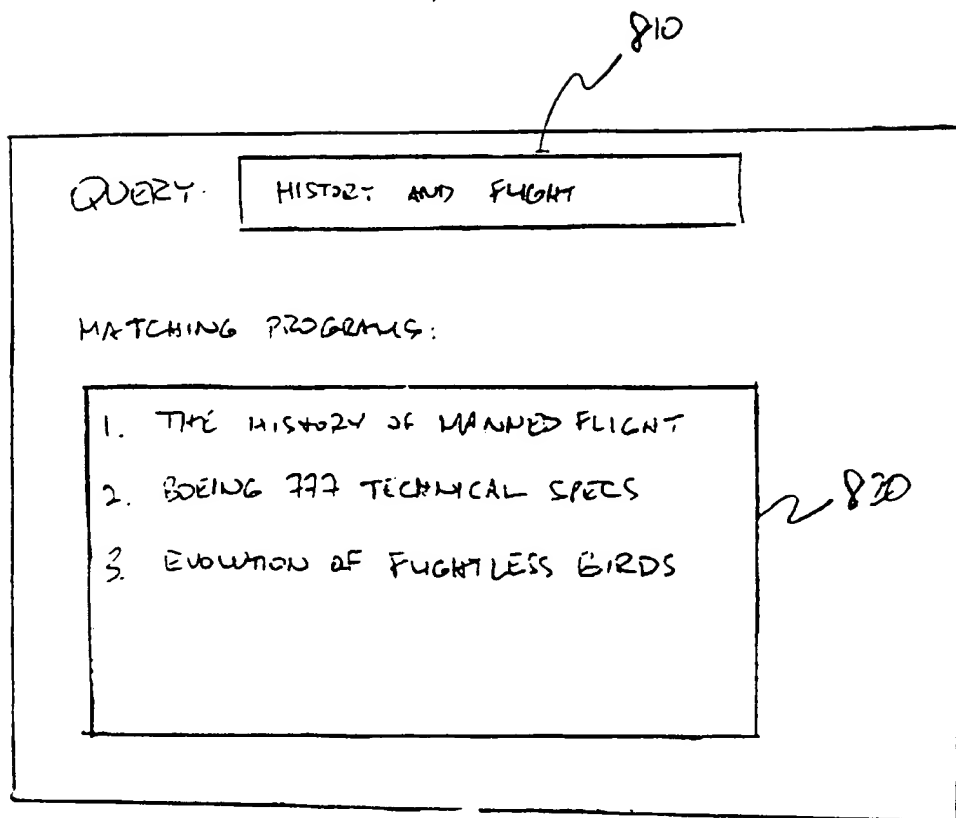
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FIG. 8



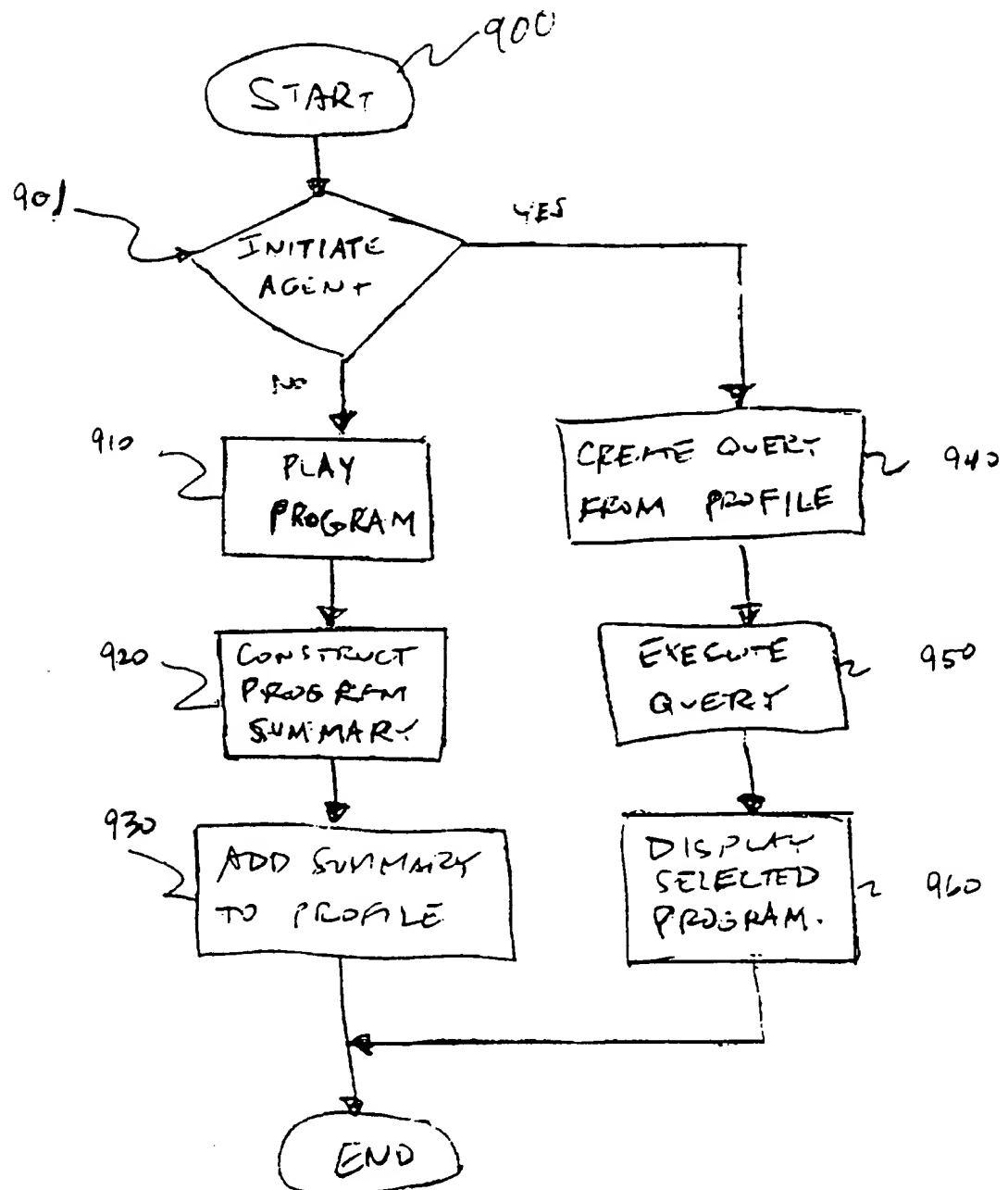
9/11

FIG. 9



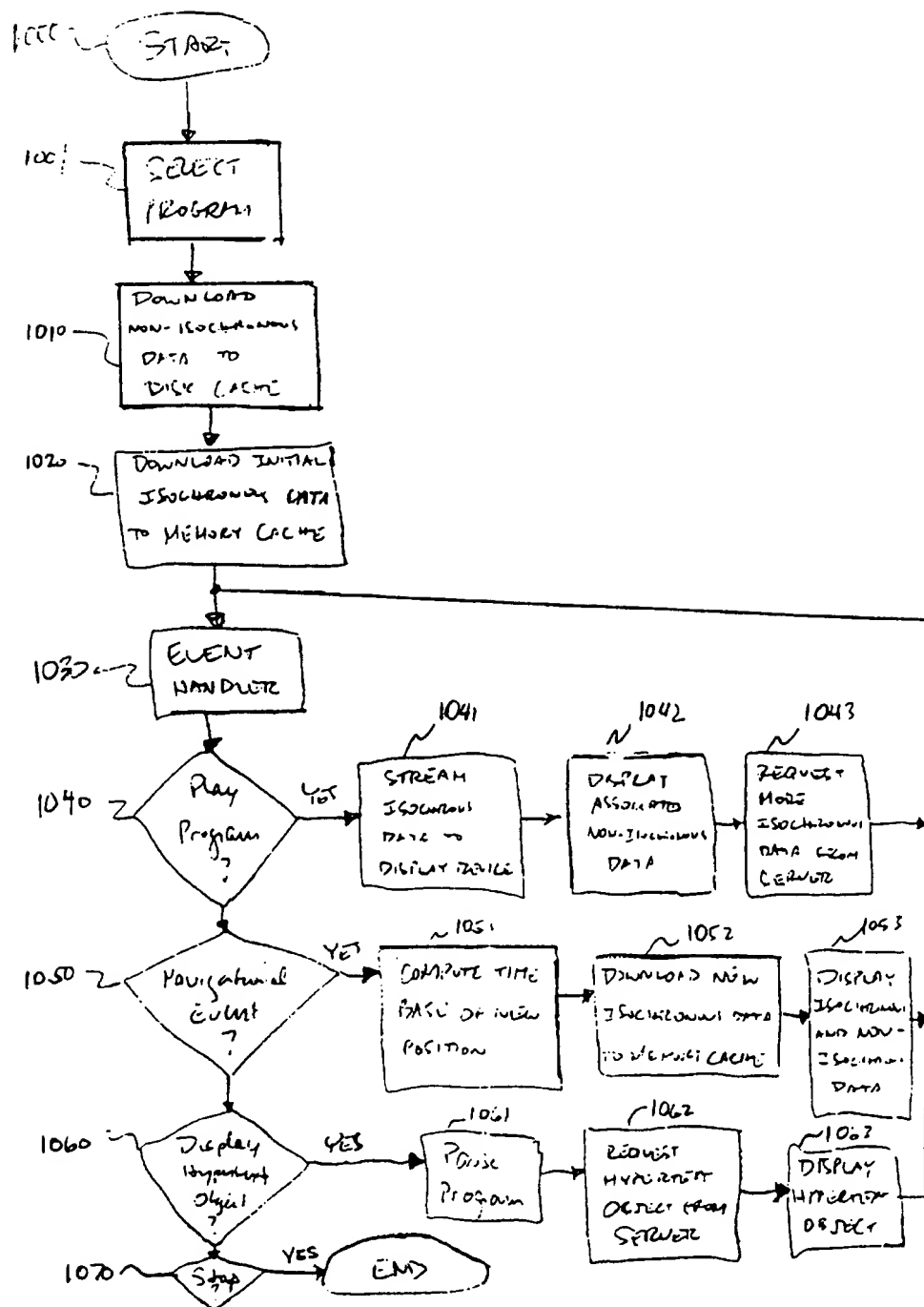
10/11

FIG. 10



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FIG. 11.



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/06982

A. CLASSIFICATION OF SUBJECT MATTER																				
IPC(6) : G06F 3/00, 3/14, 13/00, 13/42																				
US CL : 395/602, 603, 607, 807, 881, 200.02; 348/482, 515; 370/352																				
According to International Patent Classification (IPC) or to both national classification and IPC																				
B. FIELDS SEARCHED																				
Minimum documentation searched (classification system followed by classification symbols)																				
U.S. : 395/602, 603, 607, 807, 881, 200.02; 348/482, 515; 370/352																				
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched																				
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)																				
APS, DIALOG																				
C. DOCUMENTS CONSIDERED TO BE RELEVANT																				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																		
X,P	US 5,613,909 A (STELOVSKY) 25 March 1997, Figs. 2,4-6,10,12; col. 3, lines 21-60; col. 14, lines 17-67.	1-18																		
Y	SoftCom LearningNet Multimedia Distance Learning. http://www.softcom.com/Learningnet.html , 1995, Softcom. Inc., see entire document.	1-16																		
Y	The Re:Viewer Workstation Revolutionary search, retrieval, and organization of litigation discovery data, Produci News Law Technology. vol. 2, no. 6, June 1995, see entire document.	1-16																		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.																				
<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>*T*</td> <td>later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>*A* document defining the general state of the art which is not considered to be of particular relevance</td> <td>*X*</td> <td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>*E* earlier document published on or after the international filing date</td> <td>*Y*</td> <td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>*G*</td> <td>document member of the same patent family</td> </tr> <tr> <td>*O* document referring to an oral disclosure, use, exhibition or other means</td> <td></td> <td></td> </tr> <tr> <td>*P* document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table>			* Special categories of cited documents:	*T*	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	*A* document defining the general state of the art which is not considered to be of particular relevance	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	*E* earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	*L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G*	document member of the same patent family	*O* document referring to an oral disclosure, use, exhibition or other means			*P* document published prior to the international filing date but later than the priority date claimed		
* Special categories of cited documents:	*T*	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention																		
A document defining the general state of the art which is not considered to be of particular relevance	*X*	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone																		
E earlier document published on or after the international filing date	*Y*	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art																		
L document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	*G*	document member of the same patent family																		
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P document published prior to the international filing date but later than the priority date claimed																				
Date of the actual completion of the international search		Date of mailing of the international search report																		
24 JULY 1997		05 SEP 1997																		
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231		Authorized officer MENG-AI AN <i>Jon del</i>																		
Facsimile No. (703) 305-3230		Telephone No. (703) 305-9678																		

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US97/06982

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	RAVINDRAN K. ET AL, Delay Compensation Protocols for Synchronization of Multimedia Data Streams; IEEE transactions on Knowledge and Data Engineering. August 1993. Vol. 5. No. 4. pages 574-589, especially pages 574, and 588.	1-2,5,8-10,16-17
Y,E	US 5,630,117 A (OREN ET AL) 13 May 1997, col. 1, lines 62-64; col. 2, lines 50-55.	1,5,11,16
Y,E	US 5,642,171 A (BAUMGARTNER ET AL) 24 June 1997, Abstract, Fig. 6.	1,5,16
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